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U.S. Department of Energy
Vehicle Technologies Program Overview

U.S.-China Electric Vehicle and Battery Technology Workshop
Argonne National Laboratory
August 4, 2011

Henry Kelly
Acting Assistant Secretary
Energy Efficiency and Renewable Energy

Global and U.S. Petroleum Consumption Trends, 1980–2010

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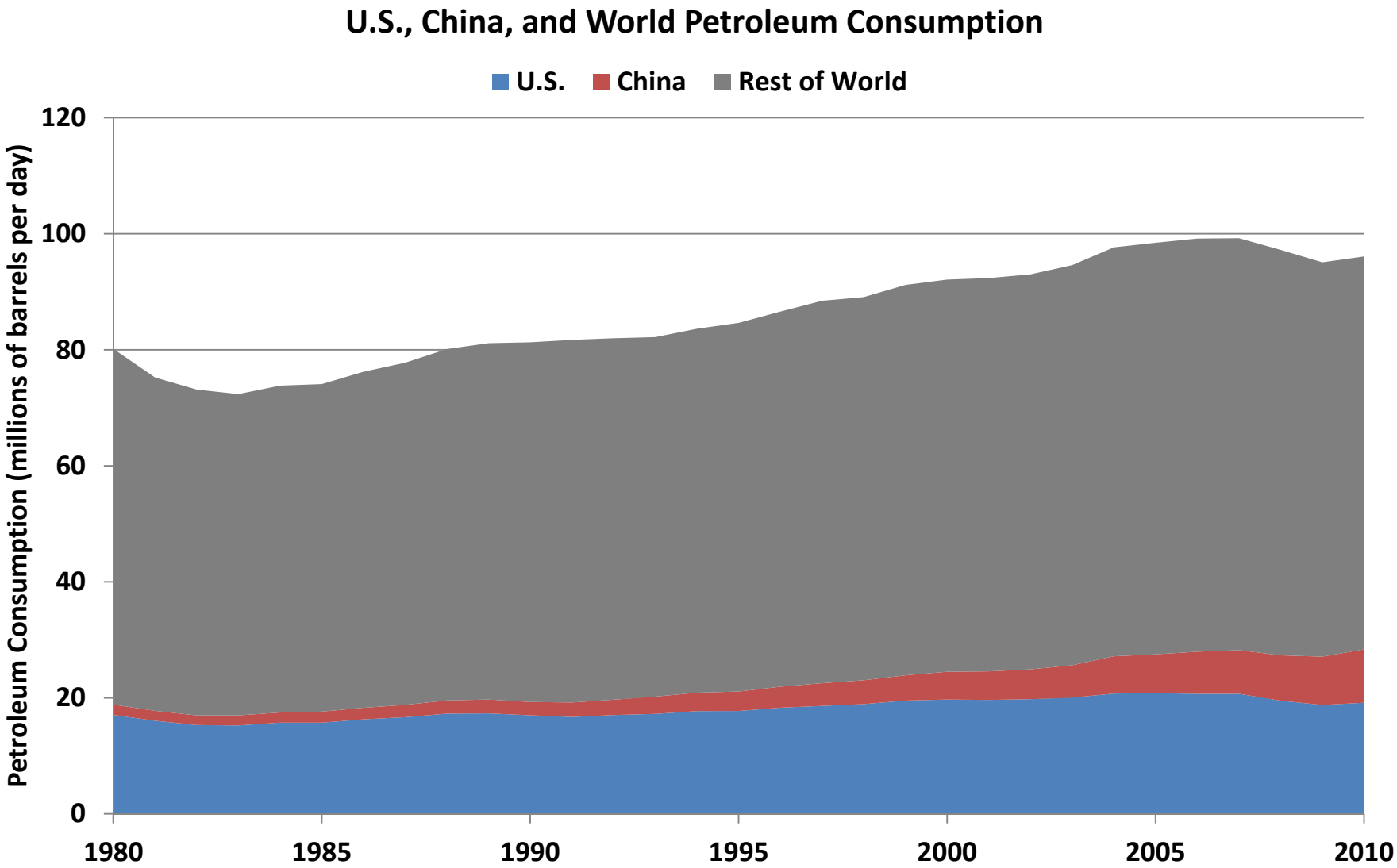

Source: EIA's International Energy Statistics (http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=5&pid=5&aid=2)

Global & U.S. Vehicle Parc, and World Population, 1970–2050

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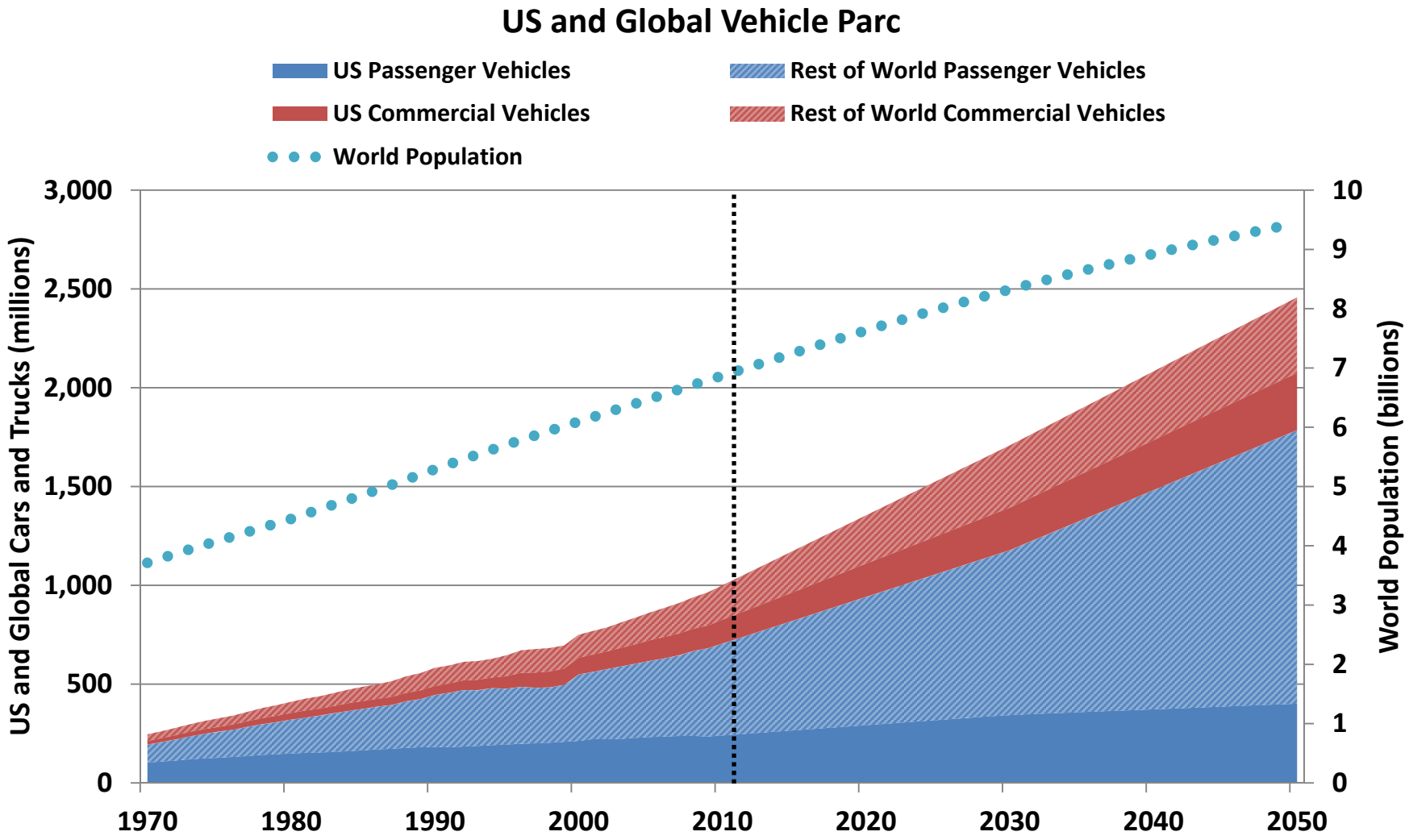

U.S. data from FHWA (1970-2009) and an Argonne National Lab VISION extrapolation of EIA's Annual Energy Outlook 2011 (with data through 2035); world data from wardsauto.com (1970-2009) and based on International Energy Agency's Energy Technology Perspectives Fig 7.14 (projections for 2030, 2050); population data from U.S. Census

The Transportation Energy Challenge

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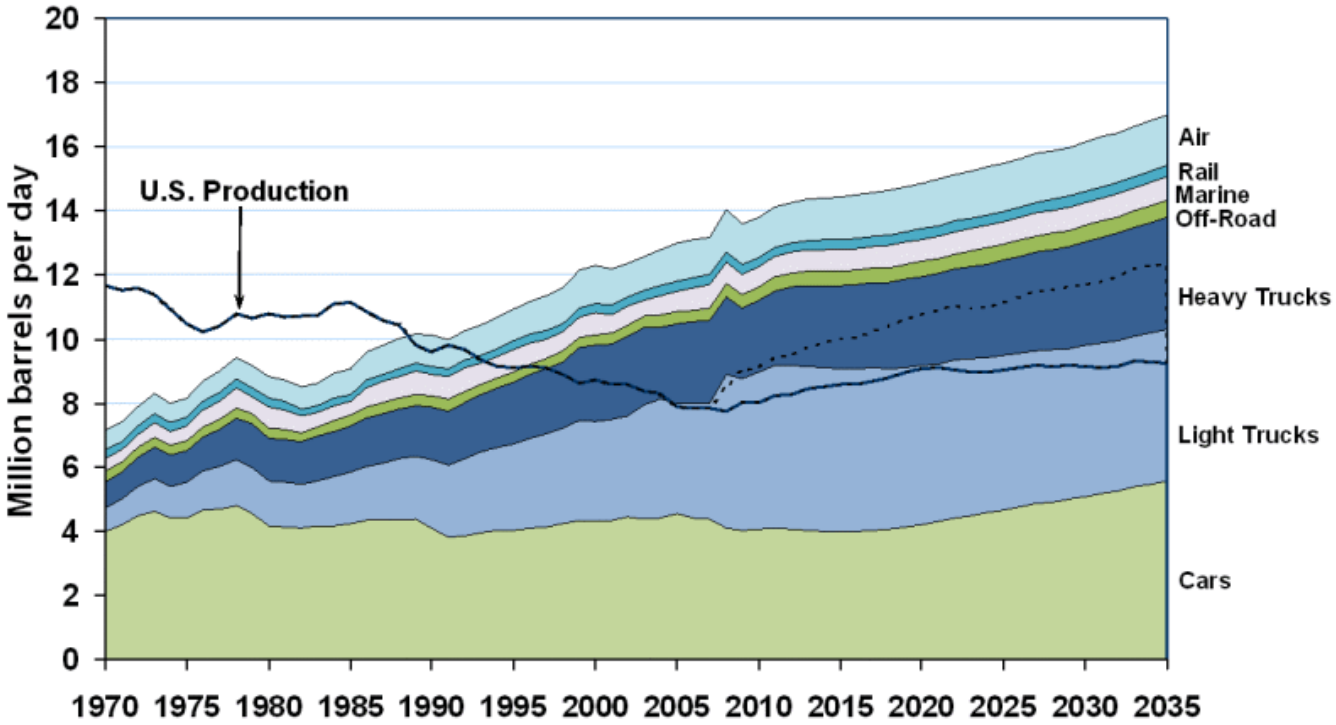
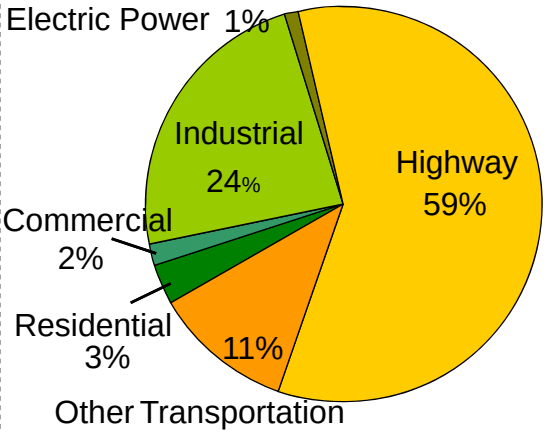


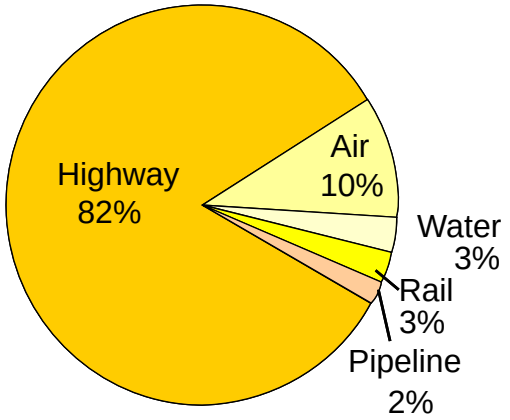
Key Facts

- **The U.S. spends about $1 billion per day to import petroleum**
- **The U.S. consumes 19.15 million barrels per day (M bpd), 22.5% of world petroleum production of 85.26 M bpd**
- **U.S. transportation petroleum use is 69.7% of total U.S. petroleum use**
- **U.S. transportation petroleum use is 172.5% of total U.S. petroleum production**

2009 Oil Use in the U.S. (19.4 MBPD)



2007 Trans. CO2 Emissions 32% of Total U.S.



2050 Transportation CO_2 – EERE's Low-Carbon Working Scenario

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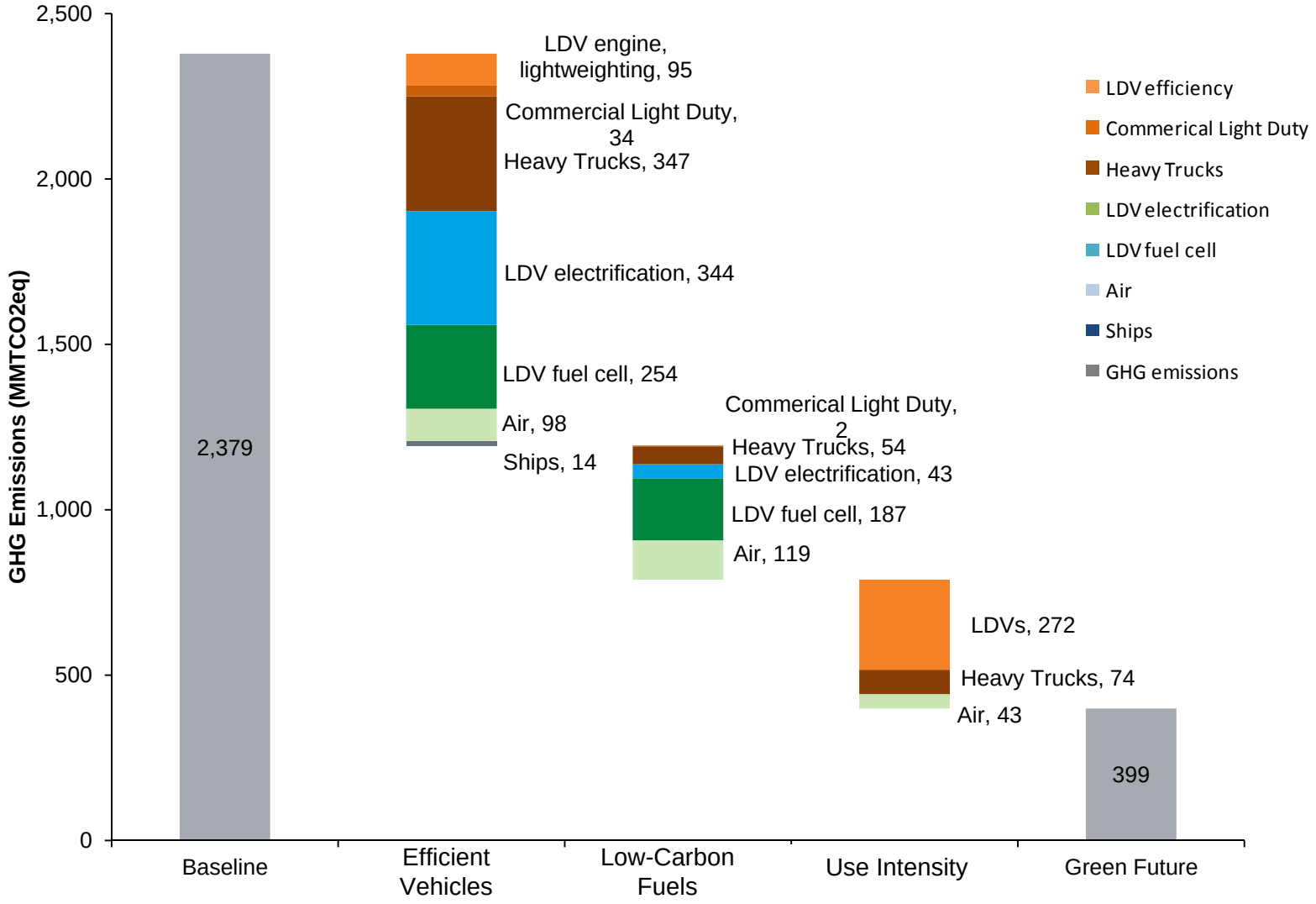

2050 Transportation Oil Consumption – EERE's Low-Carbon Working Scenario

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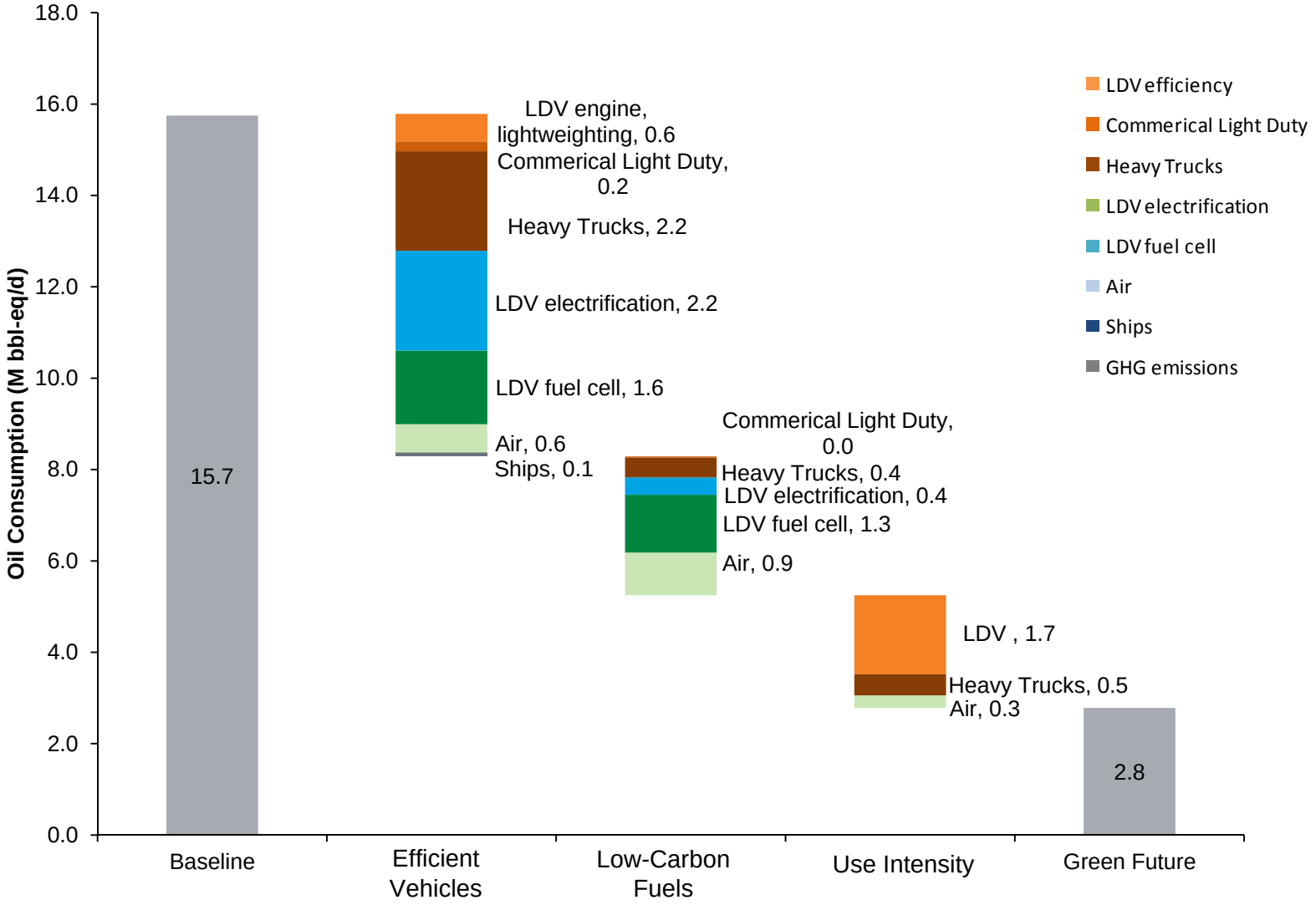

Vehicle Technologies Portfolio

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Hybrid-Electric Systems

Develop batteries, power electronics, and electric machine technologies to enable a large market penetration of electric drive vehicles. Conduct simulations and testing to evaluate components and systems. *47%*

Advanced Combustion Engine R&D

Enable extremely efficient engine operation through the development of advanced low-temperature combustion regimes and use of lower-grade waste heat.

18%

Tech Introduction

Deploy advanced technology and alternative fuel vehicles into mainstream usage through Clean Cities, with 100 local groups nationwide. Includes efforts in education, codes and standards creation, rulemaking, and regulation of state and utility fleets.

11%

FY11 Budget: $300M

Fuel Technologies *8%*

Improves the performance and emissions profile of advanced combustion regime engines through understanding of fuel properties and combustion. Validates advanced alternative and renewable fuels. Develops engine and drivetrain lubricants to reduce friction loss.

Materials Technology *16%*

Develops the materials, design tools, and manufacturing techniques that will enable automotive manufacturers to maintain current vehicle size while reducing weight by as much as 50%.

Lowering the Cost of Low-petroleum, Low-GHG Vehicle Technologies

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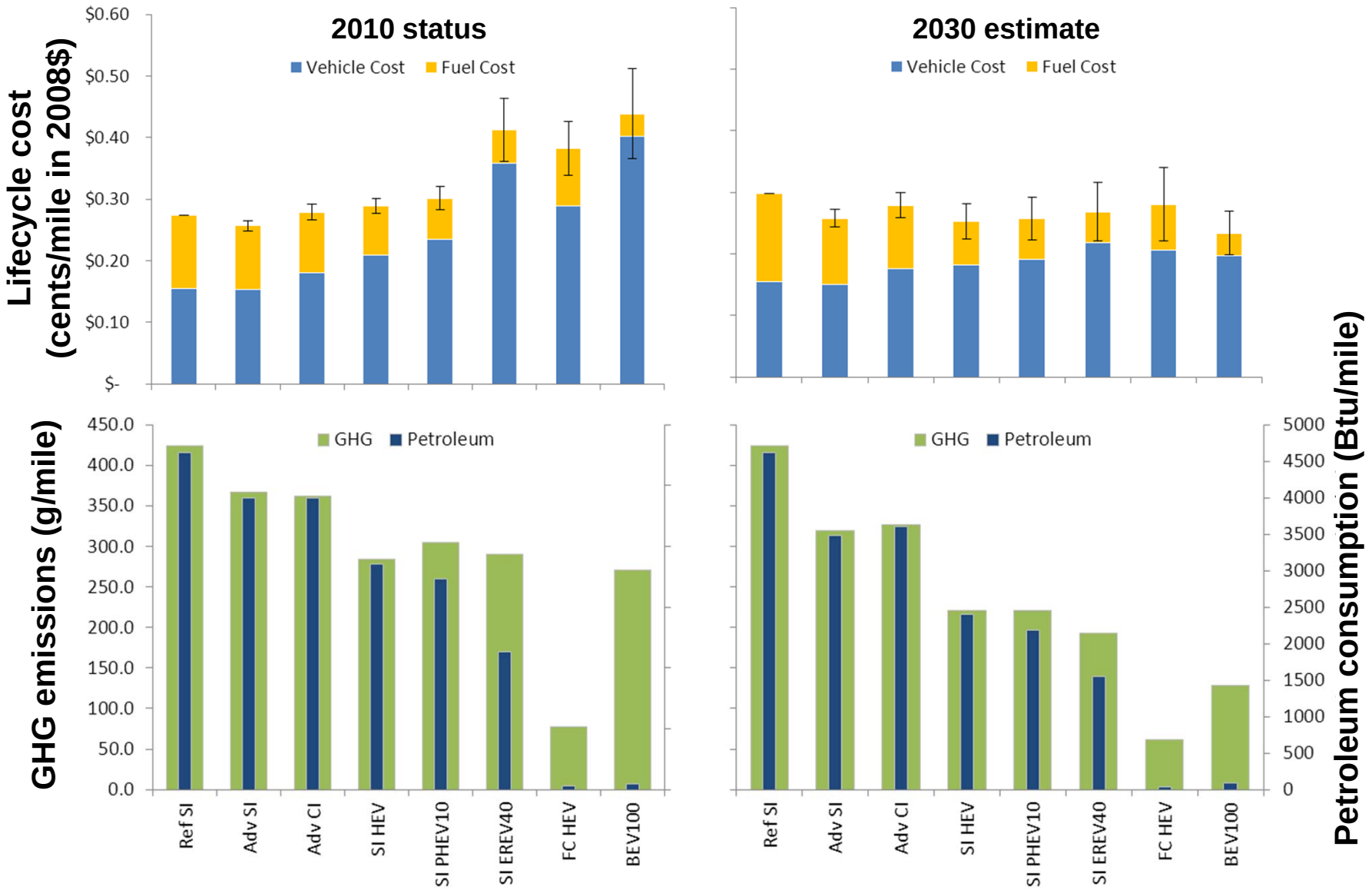

Hybrid-Electric Systems: Goals and progress

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Administration Goal:1 Million PHEVs by 2015

Types of Vehicles and Benefits

HEV →  Toyota Prius — 50 MPG

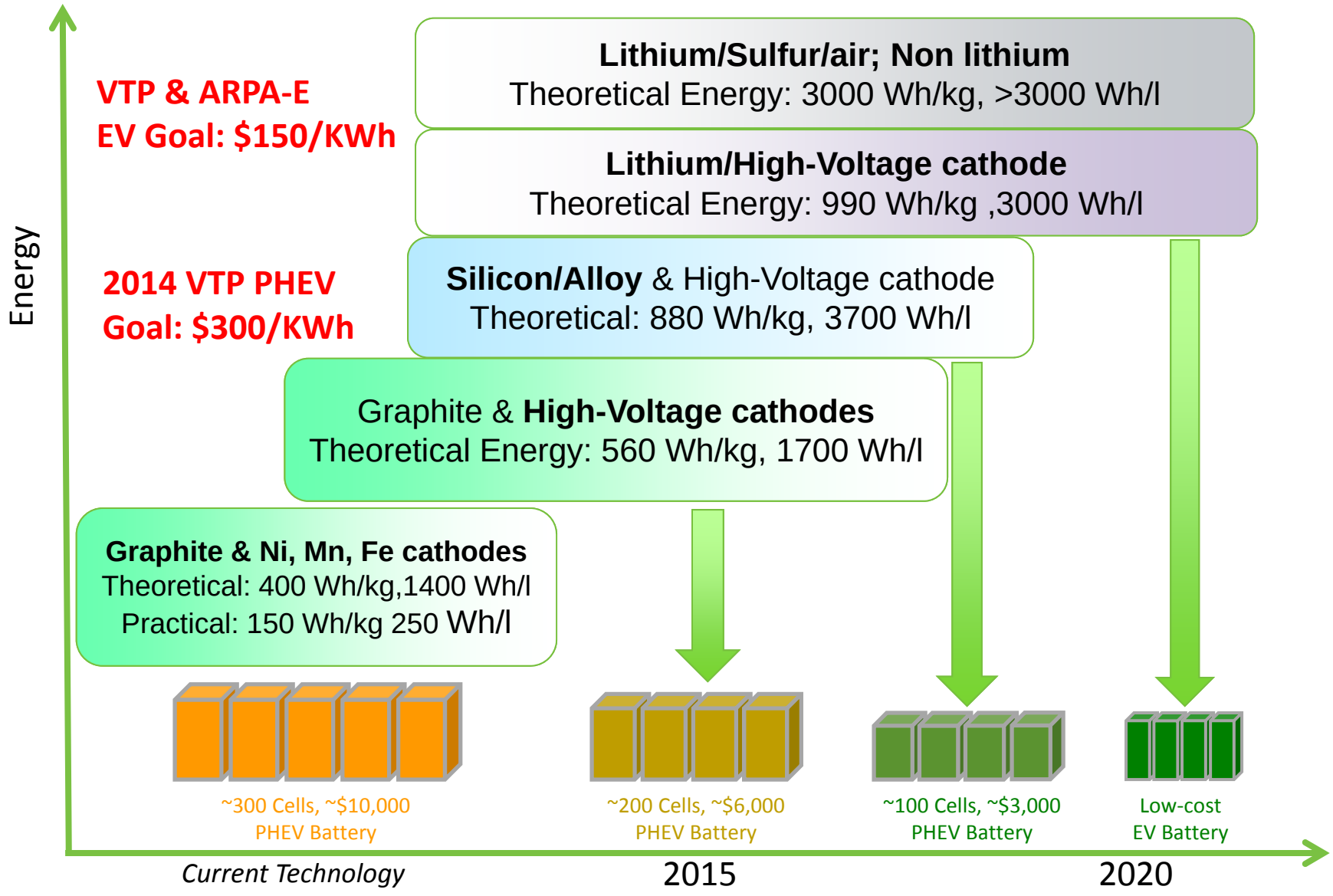
PHEV →  Chevy Volt — 100 MPGe

EV →  Nissan Leaf — All Electric

System Cost

	PHEV Battery Cost per kW·h	Motor & Electronics Cost per kW
2008	$1,000 - $1,200	$22
2010	$700 - $950	$19
2012	Goal = $500	Goal = $17
2014	Goal = $300	
2015		Goal = $12
2017		
2020	Goal = 1¢/mile ~ $125/kWhr	No Rare Earth Mat'l

EERE VTP Research Roadmap for 2015 & Beyond



Path to 2020 Traction Drive Motor Targets

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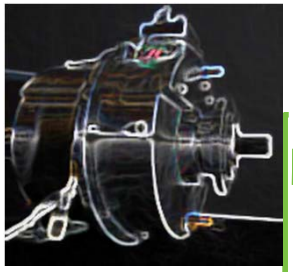


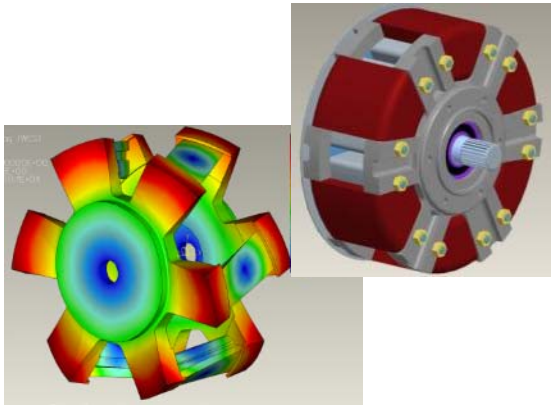
Remy (2003)
Improved winding technologies achieving higher efficiencies at low speeds - IPM

Lexus (2008)
High speed IPM to improve power density and reduce motor size

Prius (2010)
IPM using reluctance path to improve torque and power density

GE (2011)
New materials for IPMs for cost reduction

GM (2011)
Topology and control innovations with manufacturing improvements to increase power density and reduce cost for IPM



Cost ($/kW)

2015

DOE (2013)
External excitation coils to eliminate PMs achieving cost reductions

DOE (2014)
Improved switched reluctance technologies to eliminate PMs and reduce cost

2020

Emphasis on eliminating rare earth material or eliminating PMs

Power Density (kW/l)

REACT FOA **ARPA-E**

Technology Barriers to EV Adoption

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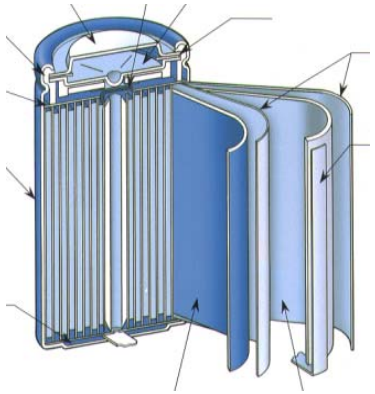

Batteries: Provide the necessary power and energy to propel the vehicle

Barriers: (1) Increasing Power and Energy Density, (2) Reducing Cost, (3) Extending Life, (4) Improving Safety

DOE Approach: R&D spanning fundamental research to manufacturing to address key barriers of cost and energy/power density while meeting requirements for cycle life, calendar life and safety

Power Electronics and Electric Machines: Manages and controls electrical energy in the system and converts electrical energy into mechanical energy

Barriers: (1) Increasing the Specific Power and Improve the Volumetric Power, (2) Reducing Cost, (3) Improving Thermal Management, (4) Eliminating Use of Rare Earth Materials

DOE Approach: R&D of wide band gap semiconductors, reduced rare earth content permanent magnets, and non permanent magnet motor technologies

Infrastructure and Consumer Acceptance Barriers to EV adoption

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Charging Infrastructure

Barriers: (1) Determining Effective Locations for Charging Sites, (2) Reducing Cost, (3) Smart Grid Integration, (4) Common Codes and Standards

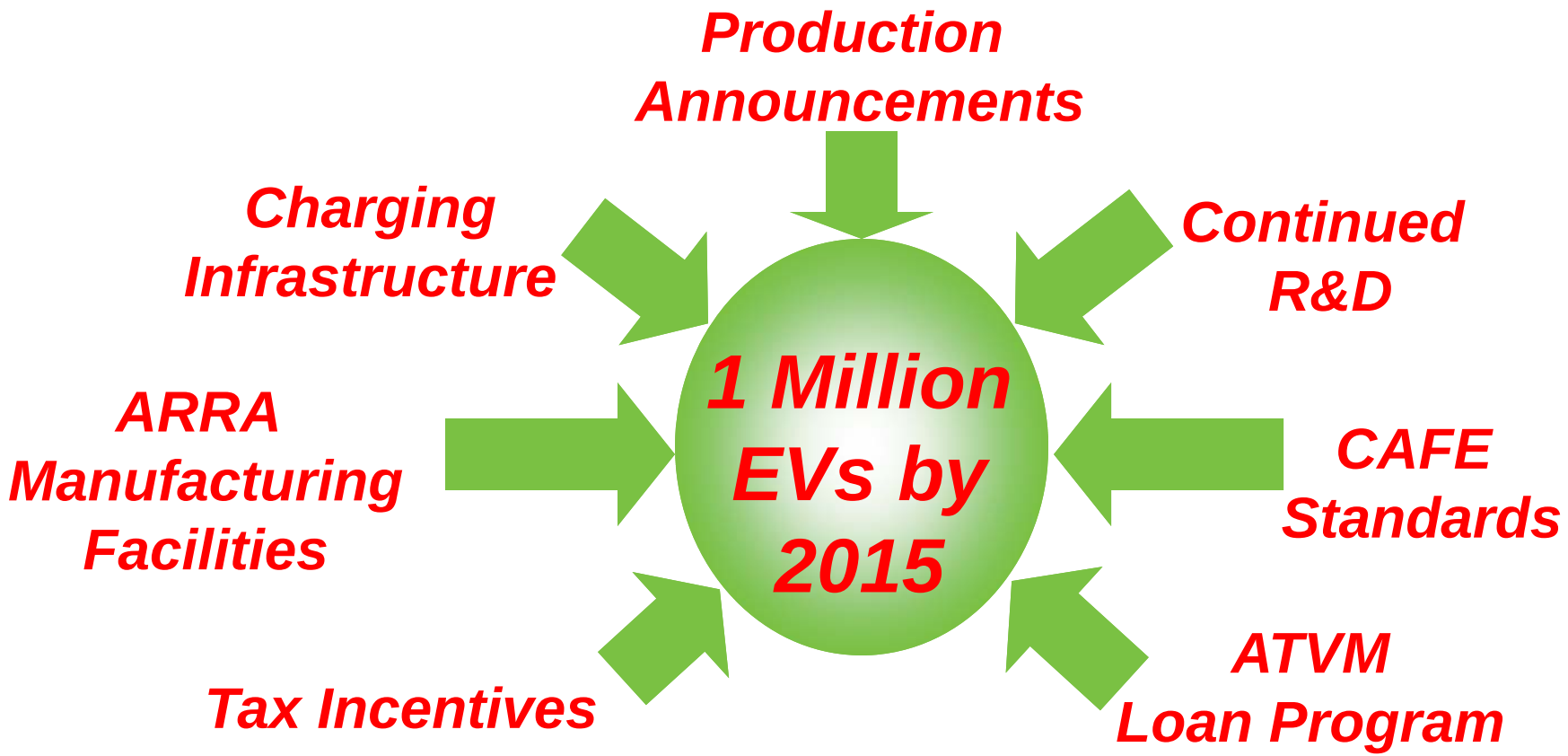
DOE Approach: Extensive demonstrations underway (13,000 vehicles, 22,000 chargers) with data collection of vehicle and infrastructure use patterns. Working to remove installation barriers at the local level (i.e., building permits) and a planned $200M cities based initiative.

Consumer Acceptance

Barriers: (1) Reducing Cost, (2) Extending EV Driving Range, (3) Non-monetary Incentives to Encourage EV Purchase (4) Codes and Standards, (5) Financing

DOE Approach: Extensive efforts by Clean Cities program to work at the local level fostering consumer acceptance. CAFÉ standards and tax incentive initiatives. Codes and Standards development underway. R&D of critical technologies to drive cost reduction and improve driving range. ATVM Loan program helping on financing.

President calls out goal of 1 million PHEVs on the road by 2015 in State of the Union address



1 Million EV Goal is a Milestone, not a Finish Line

U.S.-China EVI

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Presidents Barack Obama and Hu Jintao announced the launch of a U.S.-China Electric Vehicles Initiative – November 17, 2009

- Shared interest in accelerating the deployment of electric vehicles to:
  - Reduce oil dependence
  - Cut greenhouse gas emissions
  - Promote economic growth

- Activities under the initiative will include:
  - Joint standards development
  - Joint demonstrations
  - Joint technical roadmap
  - Public awareness and engagement

- CERC-CV (Clean Energy Research Center on Clean Vehicle Collaboration)
  - Research into various vehicle-related energy technologies, led by academia